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HURRICANE KATRINA

In the wake of Hurricane Katrina in August 2005, concerns over a potential ''toxic gumbo'' in New Orleans and concerns for public safety were paramount for state and federal agencies. This concern was evidenced by the unprecedented nature of the investigation of residential floodwater sediment contamination. Looking at the Environmental Protection Agency's residential sediment and soil sampling results, the authors attempt to place these results in the appropriate scientific context, to provide some preliminary suggestions concerning the lessons learned, and to examine policy issues that have arisen in this situation and that may arise in a future disaster. The authors believe the compressed risk management approach used by EPA may be useful in other large scale contamination events.

An Evaluation of Chemical Contamination in the Aftermath of Hurricane Katrina

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When Hurricane Katrina flooded the city of New Orleans and adjacent areas, one of many concerns in its wake was whether there was widespread chemical contamination, the so called ''toxic gumbo,'' since there are many sources of chemicals in and near New Orleans. The Environmental Protection Agency and the Louisiana Department of Environmental Quality (LDEQ) initiated an investigation into the extent of floodwater sediment contamination in residential neighborhoods, starting before the floodwaters had completely receded and prior to cleanup.[1] The sampling initially was intended to determine whether people could return to their neighborhoods for short-term visits and, eventually, to provide an assessment of the need for remediation to reduce long-term risks from exposure to chemicals.

The enormity and unprecedented nature of the investigation of residential floodwater sediment contamination is demonstrated by its design (*i.e.*, phased sampling in areas where floodwater sediment was likely to be deposited focused on finding contaminated areas, and then refining the delineation of the areas of known contamination over time), by its breath of coverage (*e.g.*,

sampling over 1,800 residential sediment and sediment/soil locations with analyses for 200 individual chemicals in the early phases),[2] by the relatively short time that it took to begin its implementation, and by EPA's and LDEQ's reporting of the results of this investigation virtually in real time on their Web sites. Some have asserted that the sediment deposited by the floodwaters is full of alarming levels of toxins.[3]

This article: (1) summarizes the EPA residential sediment and soil sampling results; (2) tries to place these results in the appropriate scientific context; (3) provides some preliminary suggestions concerning the lessons learned; and (4) examines several policy issues that have arisen in this situation, and which may arise again in either a future natural disaster, such as a hurricane, or a man-made disaster, such as an act of terrorism.

The Sampling Results

Sampling occurred in four phases, with the later phases narrowing the focus to areas where measured concentrations in the initial phases exceeded concentrations that warranted further investigation or remedial action (what we refer to in this article as ''risk management screening levels''). EPA and LDEQ used the LDEQ Risk Evaluation/Corrective Action Program (RECAP) and EPA risk criteria.[4] Both LDEQ RECAP and EPA soil levels are calculated based on standard long-term exposure assumptions.[5] Historically, EPA and LDEQ take no or little regulatory action if the risks are minimal. For cancer risks, generally this means that regulator action is not taken if the cancer risk from exposure is less than one in 1 million (10^{-6}). Regulators generally take action when the cancer risk exceeds the one in 10,000 (10^{-4}). For noncancer risks, action is not taken generally unless the concentration results in a lifetime exposure that is above the exposure level the regulators deem to be without an appreciable risk of deleterious noncancer effects during a lifetime. Typically, this exposure level is based on a no effect level divided by various uncertainty factors and/or safety factors.[6] Generally, EPA's methodology provides estimates that are uncertain, but ''are more likely to overstate than understate hazard and/or risk.''[7] The ''detection of a single chemical in soil that is greater than the screening level does **not mean that health risks exist**,'' but only that ''additional evaluation of available data and/or site conditions may be indicated.''[8]

Thus, each phase needs to be described briefly because the later phases concentrated on providing more delineation of the locations where in the earlier phase, the residential floodwater sediment exceeded risk management screening levels. The percentage of floodwater sediment samples containing concentrations exceeding the EPA risk management screening levels and average concentrations in the later phases of EPA's sampling should overestimate the percentage of the city as a whole containing concentrations above these screening levels and the mean concentrations. This is because the later sampling primarily focused on areas known to have concentrations in excess of the EPA risk management screening levels and, therefore, ignored the uncontaminated areas found in the earlier phases, ignored areas where the contaminated floodwater sediment found in Phase I was removed, and did not take into account the fact that the chemical concentrations of the petroleum related chemicals decreased from September 2005 to June 2006 due to biodegradation (See discussion below.).

This compressed risk management approach (although it is likely to overestimate regulatory risks) was innovative and appropriate for the situation. This same approach may be useful in other future large scale contamination events, as long as there are existing, or easily derivable, risk management screening levels.

Phase I. The Phase I floodwater sediment sampling from Sept. 10 to Oct. 14, 2005, involved 450 samples[9] taken from areas where the soil was ''most likely to be contaminated, such as sediment with stains or odors, and soils collected in drainage paths such as curbs, storm drains, etc.''[10] EPA found ''large portions of the impacted area had little or no sediment deposited,'' therefore, ''[s]oils in areas that did not flood were generally unchanged by Hurricane Katrina'' (*see* Figure 1 at the end of this article, which shows areas where currently there is no or little sediment, the areas sampled, and the location of one large diesel oil release).[11]

However, conditions have been constantly changing. When EPA resampled 145 locations after the initial Phase I sampling in September 2005, the sediment already had been removed in all but 14 locations.[12] Therefore, by the end of October, only 3.1 percent of the original worst-case sampling locations—14 out of the original 450 locations—contained sufficient sediment to sample since the sediment deposited by the flooding had been removed.[13]

These samples were analyzed for over 200 individual chemicals. Because a large diesel fuel spill was known to have occurred and there were many potential small releases of gasoline and diesel fuel from vehicles and service stations, EPA also analyzed for diesel range organics[14] (or DRO, which measures the sum of the heavier individual constituents in diesel fuel), gasoline range organics[15] (GRO, which measures the sum of the lighter constituents in gasoline), and ''hydrocarbons, petroleum (unspecified mix),'' as well as the individual indicator constituents of petroleum products, such as benzo(a)pyrene (BaP), the other polycylic aromatic hydrocarbons (PAHs), benzene, toluene, ethylbenzene, and xylenes.[16] The general indicators of petroleum contamination are very rough screening tools. They provide little information on whether the particular petroleum hydrocarbons in the sample affect people.[17] LDEQ guidance specifies that one should identify and quantify the individual constituents of petroleum (such as benzene and B(a)P).[18] Thus, by combining a quick screening use of the petroleum screening indicator DRO and the results of the sampling for individual constituents of petroleum (such as B(a)P), one can assess the presence and potential risk from petroleum.

Initially, in some localized areas, concentrations of arsenic, petroleum products, or lead exceeded EPA risk management criteria based on long term exposure (30 years) and/or LDEQ Risk Evaluation/Corrective Action Program levels.[19] Lead was found in 5 percent of the Phase I samples at pre-Katrina levels.[20]

Phase II. The Phase II floodwater sediment sampling from Oct. 29 to Nov. 27, 2005, involved an additional 280 individual samples—each of which were analyzed for over 200 chemicals—focused on the Lower Ninth Ward and St. Bernard Parish, the areas of most serious flooding, and identified areas larger than 3 acres that

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contained concentrations that exceeded the risk management screening levels—a risk level EPA and LDEQ historically have used to determine whether regulatory action is warranted.[21]

Lead, the only chemical found above its screening level in Phase II, was detected above the 400 mg/kg screening level in four locations in St. Bernard Parish.[22] According to a report, which includes data from Phase I and II, from the Natural Resources Defense Council, 5 percent of the lead samples in the Greater New Orleans area and 7 percent of the samples in Orleans Parish had lead levels exceeding 400 mg/kg, although the levels in certain neighborhoods were as high as 38 percent.[23] Since Phase I determined that the vast amount of locations, 96.9 percent, had no sediment, these 280 locations were true worst case locations. Phase I and II sampling combined identified a total of 43 areas for further investigation. [24]

Phase III. The Phase III Focused Sampling of soil and sediment that ended Feb. 22, 2006, involved taking 147 composite samples in 43 specific flood-impacted residential areas where *previous sampling found concentrations* of arsenic, lead, or petroleum indicators *in excess of risk management screening levels*.[25] The purpose of this sampling was to determine whether the locations with the elevated levels of these chemicals were isolated or whether they were representative of a larger contaminated area.

Arsenic levels did not exceed EPA's safe risk management level and the only area with PAH contamination in excess of risk screening levels was an area near the Agricultural Street Landfill, a superfund hazardous waste site still undergoing cleanup. Lead concentrations exceeded 400 mg/kg (the screening level) in 57 out 147 composite samples (38.1 percent), with the highest concentrations in soil, as opposed to flood sediment samples.[26]

Phase IV. Phase IV Sampling of Residual Sediment in flood impacted areas in February 2006 involved taking 712 samples from 586 locations in Orleans and St. Bernard Parishes based on a 200 foot grid.[27] EPA was unable to collect samples at another 1,090 locations because either no or insufficient sediment was present to sample or the location was in a commercial area, *i.e.*, only 35 percent of the locations had sufficient sediment or were residential.[28] Arsenic, lead, and B(a)P each were detected in only one sample in concentrations exceeding the risk management screening level (*i.e.*, the one in 100,000 excess lifetime cancer risk level for arsenic and benzo(a)pyrene or the 400 mg/kg risk management screening level for lead), which equates to roughly 0.4 percent of the samples (See discussion below for further explanation of these results.).[29]

Discussion of the Results

Chemical Concentrations Safe and/or Typical. EPA noted that ''with a few notable exceptions, the chemistry of soils and sediments is little changed from pre-Katrina conditions, and levels of contaminants are similar to other older urban centers around the country'' (see Table 1, next page).[30] The following addresses the claims that there were excessive levels of arsenic, petroleum, and lead.

Arsenic. It has been claimed that the ''levels of arsenic in 95 percent of the sediment samples collected by the EPA in the greater New Orleans area would potentially pose a significant cancer risk, according to EPA guidelines,''[31] *i.e.*, the EPA arsenic ''soil screening level'' of 0.4 mg/kg.

It is literally true that arsenic was present in residential floodwater sediment at concentrations greater than the ''soil screening level'' of 0.4 mg/kg chosen by the environmental group. This is true of virtually all of the soil and sediment on the face of the planet because arsenic is an element present in most soil at concentrations above 0.4 mg/kg.[32]

The soil screening levels discussed above, according to EPA guidance, ''**are not national cleanup standards.** Soil screening levels alone do not trigger the need for response actions or define 'unacceptable' levels of contaminants in soil'' and EPA and LDEQ policies require the background concentration of arsenic to be used as a risk management screening level, not 0.4 mg/kg.[33] (bold face in original).

The mean arsenic concentration in the New Orleans sampling (approximately 10 to 12 mg/kg, see Table 1, next page)[34] corresponds to a three in 100,000 lifetime risk level, using EPA's historic regulatory risk calculation.[35] This risk level is below the one in 10,000 risk level that EPA and the courts have concluded is ''safe.''[36] In fact, the measured arsenic soil concentrations are within the range of background for New Orleans, and real world background generally (based on prior government studies and the scientific literature).[37]

In summary, there is no significant risk presented by the measured arsenic concentrations and no increase in risk because these levels generally are within the range of background arsenic levels in soil.

Petroleum. Overall, very few of the locations sampled had individual petroleum-related constituent concentrations that exceeded EPA and/or the LDEQ RECAP soil screening levels.[38] There is ''one localized area in the vicinity of the Agriculture Street Landfill that had elevated levels of benzo(a)pyrene.''[39] However, EPA is working with LDEQ and its other federal partners to determine the appropriate course of action in this localized area.''[40] The regulatory risk that corresponds to the average concentration of B(a)P calculated by an environmental group for areas with detectable levels (i.e., 1.4 mg/kg using data from the fall of 2005) is eight in 1 million risk level, well below EPA's safe risk level.[41] As noted above, this average concentration is an overestimate of the true concentration. Additionally, some of the PAH levels found also are within the range of background concentrations found nationally for benzo-(a)pyrene and certainly typical for urban areas (See Table 1.).

EPA also compared concentrations of petroleum related chemicals at similar locations from September 2005 to June 6, 2006, and determined that the concentrations ''are decreasing over time through a combination of factors including natural degradation processes and sediment displacement or removal at all but one location,'' in many cases by more than 90 percent.[42] However, future sampling is being conducted to ensure the concentrations of petroleum hydrocarbons continue to decrease. Thus, the petroleum screening concentrations and individual constituents listed in NRDC's report significantly overestimate the long-term concentration of

(and, therefore, risk from) petroleum products in floodwater sediment and soil.

LDEQ concluded that the PAHs found are ''of the type commonly found in petroleum products, exhaust from automobiles, asphalt, etc.'' and that the elevated levels of petroleum-related chemicals were ''likely attributable to surface runoff from roadways and parking lots in combination with releases of petroleum products from vehicles submerged under floodwaters.''[43]

Lead. A lead concentration of 400 mg/kg is EPA's and LDEQ's soil cleanup level and the federal ''soil-lead hazard'' level [44] for housing developments, which are subject to the Department of Housing and Urban Development (HUD) lead-based paint rule.[45]

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TABLE 1: SUMMARY OF CHEMICAL DATA AND COMPARISON TO RISK MANAGEMENT SCREENING LEVELS

CHEMICAL	Risk Management EPA/LDEQ Screening Level+	EPA Acceptable Risk Range (10^{-6} to 10^{-4})	Background	Comments on the Distribution of Concentrations	Natural Resources Defense Council's 'Average' of Detected Levels at Worst-Case Locations
	ALL MEASUREMENTS IN MG/KG (PPM)				
Arsenic	**12**[46]	0.39 – 39.0	12 (LDEQ)	Found in most samples, but at background[47]	<10.6, <11.8 3 x 10^{-5} lifetime risk level, using EPA's standard assumptions[48]
Lead	**400**	400	Low 20s[49]	Most below 400 mg/kg Small percentage of soil samples >400 mg/kg near pre-1978 buildings	<94 (5% exceeded 400 mg/kg) <108 (7% exceeded 400 mg/kg)[50]
DRO (diesel)	**650**[51]	—	—	Most below 650 mg/kg, which is not risk based. Many of > 650 mg/kg have been removed. Concentrations are decreasing over time.	<524 <957
B(a)P (risk indicator component of TPH)	**0.33**[52]	0.33 – 33	Non-detect to 1.3 (national)[53] 0.1 to 0.66 (pre-Katrina)[54]	Found in a very small percentage of samples, many of which have been removed. Concentration decreasing over time.	<1.0 <1.4 (4.2 x 10^{-6}, risk level, using EPA's standard assumptions)

+/ **The risk management ''screening level'' concentrations used by EPA, LDEQ, and the Agency for Toxic Substance and Disease Registry (ATSDR) are the LDEQ Risk Evaluation/Corrective Action Program (RECAP) and EPA's risk criteria (*e.g.*, range of in one million [10^{-6}] to one in ten thousand [10^{-4}] risk of an individual developing cancer over a lifetime, or a non-cancer health-based endpoint) based on long-term (30 years) residential exposure assumptions.**

DRO (diesel range organics): An analytical technique that measures the portions of petroleum products that are likely to be present in diesel fuel (*i.e.*, the heavier end petroleum products). Other indicators of petroleum spills are gasoline range organics (or ''GRO,'' which also has a risk management options level of 650 mg/kg)[55] and the total petroleum hydrocarbons (TPH) of 1,800 mg/kg,[56] which measures all of the hydrocarbons present in petroleum products.

B(a)P: Benzo(a)pyrene is the primary risk indicator component of petroleum products.

NRDC ''average'' chemical concentration actually is the average only of the concentration in areas where the chemical was detected. It is a worst case overestimate of the true average concentration. For example, NRDC calculated the average concentration for the petroleum product indicators only for the samples where diesel fuel levels were detected.[57] As a result, there is considerable uncertainty in this measurement and measurements indicating that diesel fuel was not present were ignored in the calculation of the average. As a result, the ''actual'' average concentration is dramatically lower than calculated using the preliminary sampling data.[58] Given the removal of floodwater sediment, the additional data, and changes in concentration, it would be preferable to calculate a current average concentration (both citywide, within areas of known elevated levels of lead or petroleum, and, where appropriate and possible, for neighborhoods).

The sampling from each phase found significantly different percentages of sampling that exceeded 400 mg/kg for several reasons.[59] First, the percentage of samples containing lead concentrations in excess of 400 mg/kg in Phase III is higher than in Phase I and II. The reason is that the Phase III sampling was taken only in locations where a risk management screening level was previously exceeded. Obviously, where the later sampling concentrated on the areas known to contain concentrations that exceed screening levels, the percentage of samples which exceed these screening levels should increase. As noted in the NRDC report, the percentage of exceedance depend upon whether one looks at the citywide values or in neighborhoods where there previously were elevated levels (3 percent versus 38 percent).

According to EPA, understanding the source of lead ''informs'' agencies on the ''best course of action to take to address the elevated levels.''[60] EPA's special study of lead determined that the geographic pattern of lead near housing constructed prior to 1978 (*i.e.*, when lead-based paint was banned), the fact that it is primarily in

soil, and EPA's special sampling to identify the source of the lead ''suggests that the primary source of lead in the soil samples collected by EPA is lead-based paint''[61] and is not related to the hurricanes.

Therefore, although for the city as a whole had lower exceedances of 400 mg/kg of lead, in some neighborhoods, up to approximately 38 to 40 percent might fail the 400 mg/kg both before and after Katrina (See Table 1.).[62] The 38 percent exceedances are similar to a pre-Katrina study of New Orleans that indicated about 40 percent of nearly 5,000 soil samples had lead levels above 400 mg/kg.[63] Nationwide, EPA estimates that approximately 23 percent of privately owned homes in the US built before 1978 contain soil-lead levels above 400 mg/kg,[64] In 2000, 14 percent of the children tested in New Orleans had levels in excess of the federal advisory level of 10 micrograms per deciliter of blood, which is a citywide figure.[65]

Actual site-specific risks may be lower than indicated by these statistics because risks are related to the average concentration of lead in the residential soil to which a resident is exposed, the degree to which the lead is released by the soil, and other site-specific conditions.

Federal, state, and local government agencies have recommended lead soil risk reduction measures for several years. EPA has reiterated these recommendations in its post-Katrina responses .[66] Many (including those whose property contain lead levels in excess of 400 mg/kg) do not care whether the lead was present prior to Katrina or if EPA has legal authority to act, they ''simply'' want the levels reduced.

Summary. In summary, the initial concerns about the floodwaters containing a ''toxic gumbo'' that may cause widespread residual chemical contamination fortunately have not been found by sampling, except in areas of known spills. This finding was reconfirmed at a four-day session at the American Chemical Society meeting in San Francisco, Calif., in September, where ''scientist after scientist confirmed similar results: they have found no . . . widespread elevated levels of pesticides, petroleum products or metals in the sediment.''[67]

Specific spills and other pre-existing conditions that may have been uncovered by the sampling are being further assessed. In one case, a large clean up has begun. In other cases, further evaluation determined that remediation is not necessary. Other areas are still under evaluation.[68]

Policy Issues and The Future

The situation in New Orleans presented a decision-making problem on a scale not faced previously. However, the problems being faced today in New Orleans may be repeated during other natural and man made disasters. Thus, it is wise to learn the policy lessons to better address new problems in the future.

1. Practical, cost effective, and timely guidance for remediation of any properties contaminated by Katrina requires the type of flexible, phased, hybrid screening sampling and expedited analyses that EPA and LDEQ utilized in the New Orleans area. The phased, hybrid screening approach that EPA, LDEQ, and ATSDR are following in New Orleans is reasonable and has focused the sampling only on those areas which need further testing. EPA and LDEQ, within a relatively short period of time, have designed, implemented, and interpreted the results of one of the largest urban sampling efforts conducted to date and have done so in a very transparent manner using their standard methodologies.

To date, existing institutions (local government, insurers, banks, etc.) have not conducted, and could not handle the volume of site-specific assessments using standard decisionmaking processes. Prior to Katrina, there were no ''off-the-shelf'' examples of how to perform citywide sampling in an expeditious manner that could have been directly applied. In our opinion, it would be too costly and take far too long to perform extensive sampling and site-by-site risk assessment for each residential property. Furthermore, risk management screening demonstrates that such an approach is not necessary. Even the compressed risk management screening level approach used by EPA and LDEQ is costly.

For planning purposes, property specific information may not be necessary, cost-effective or feasible when determinations must be made quickly. In the absence of coordinated, rapid decisions and answers to the many outstanding questions, individuals will proceed to define the future of New Orleans based on their own circumstances and desires. In that event, uniformity and equity are likely to suffer.

Furthermore, while an informed individual homeowner can assess the contamination on his or her property, in the absence of government support for testing and cleanup, the responsibility and cost would fall disproportionately on the poor. The end result when applied to New Orleans effectively would mean that little or no testing would be conducted on individual properties.

2. The key habitability question (which involves consideration of biological contamination, mold issues, and the potential for future floods) needs to be incorporated into the reconstruction decisions. It is not easy to make cleanup and habitability decisions when the area potentially affected is as large as the city of New Orleans. The determination of habitability and how habitability fits into the overall reconstruction scheme is a multifaceted issue that goes beyond the mere evaluation of chemical contamination.

The habitability assessment should address potential concerns posed by the presence of mold and airborne mold spores in homes. Unlike air, water, and soil contamination, currently there is little scientific basis for evaluating the potential effects of mold on human health, or for developing related risk-based action or cleanup levels. Airborne mold counts of 50,000 spores/m^3 are considered very high. Spore counts as high as 650,000 spores/m^3 were observed by NRDC in a home in mid-city New Orleans after Katrina.[69] Because there are no standards to which these mold counts can be compared, there is no clear regulatory responsibility among federal agencies for addressing indoor air issues. High mold counts are cause for concern, however, and both NRDC and EPA recommend that returning residents remove all porous construction materials, including carpets and drywall, from flooded homes and use respiratory protection while doing so. The pervasive nature of mold contamination in New Orleans in the aftermath of Hurricane Katrina and the lack of knowledge on the risks of mold and airborne mold spores suggest that additional research is needed to improve the ability to respond to this problem.

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The federal, state, and local governments and private sector institutions such as insurance companies need to integrate into future land-use and redevelopment decisionmaking the best scientific understanding of risks presented by future flooding, future levee failure, mold contamination, and residual levels of chemicals in floodwater sediment and soil (regardless of the source of this contamination).

Developing a specific balance for this decisionmaking is a societal decision that is beyond the expertise of the authors and scope of this paper. That said, master reconstruction plans, zoning, and other mechanisms exist to integrate the actions of the federal, state, and local governmental entities and of the private sector. The existing data suggest the level of chemical contamination may be the least of the concerns facing stakeholders.

There is, and will continue to be, situations where it is necessary to determine with certainty whether a specific residential property is or is not contaminated. For example, as redevelopment projects in formerly flooded areas are implemented, it is likely that case-by-case determinations may be necessary. Similarly, if large areas were ''taken'' for redevelopment, in some cases, the significance of the presence and source of chemicals may need to be addressed. Thus, there should be adequate checks and balances—such as scientific peer review, public involvement, cooperative efforts between local, state, and federal agencies, and public-private partnerships— placed on the methods used to interpret the existing data to ensure the existing data are not misused.

3. A healthy policy dialogue is necessary on these issues. Decisions about New Orleans and future habitability are likely to require input from a wide range of stakeholders. The criteria by which such decisions are made should be uniform, transparent, and consistent with existing hazardous waste and natural disaster cleanup criteria. Fortunately, the sampling to-date suggests only a very small number of locations, if any, contain chemical concentrations from any source that warrant remedial action.

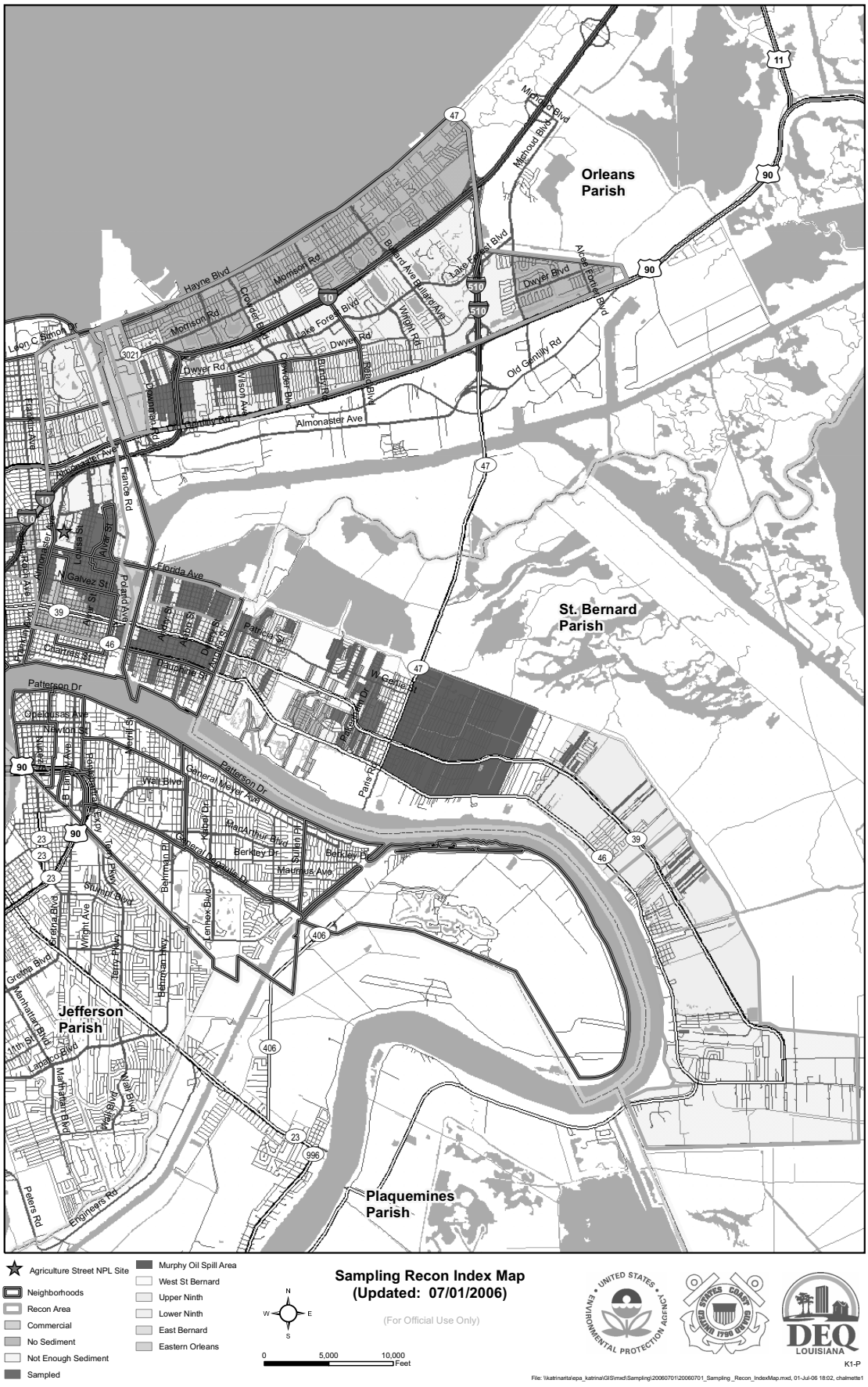
The critical test of a legal process is not whether an agency chooses the alternative preferred by the public, but whether the public perceives that the process is fair. A necessary predicate to fairness is communication of the nature of such a process. The discrepancy between some of the concerns expressed by local residents and environmental groups versus the results of the EPA and LDEQ sampling efforts suggests that despite the unprecedented efforts to involve the public, additional efforts to maintain a dialogue with the public may be needed. The experience in New Orleans once again reflects the difficulty associated with calculating risks, communicating with the public about such risks, and building trust about risk, particularly in the midst and aftermath of an emergency.

In particular, the sampling and risk assessment scheme for diesel gasoline fuel spills is less straight forward than for many chemicals. Therefore, EPA and LDEQ should provide a more explicit and detailed explanation of their reasons for concluding that fuel measurements were within acceptable ranges and/or within range of background. Because of the authors' experience in environmental sampling and assessment, the approach taken by EPA and LDEQ was intuitively understandable. However, even the authors found that recreating the decisionmaking process was time consuming and, at times, made more difficult because there was no step-by-step explanation.

4. A key policy issue is whether reconstruction of New Orleans should include cleanup of pre-Katrina contamination. EPA and LDEQ repeatedly note that the level of some isolated contaminants is the same as it was before Hurricane Katrina. Clearly these levels were not caused by the storm. However, the local residents and other groups, not surprisingly, are demanding that the soil be safe regardless of the cause or who pays. Thus, the question arises as to whether individuals might be willing to delay their return to their properties, and support governmental decisions about which neighborhoods might be rebuilt, based on the levels of chemicals in the sediment or soil, even if these levels are the same or even reduced from the levels that existed prior to Hurricane Katrina.

The ongoing cleanup decisionmaking process also might provide an opportunity to reduce exposure to toxics and other contaminants, regardless of whether the contamination was pre- or post-Katrina (*e.g.*, ensuring that any soil contaminated from lead-based paint, or lead-based paint remaining in homes is removed). As a practical matter, such an approach is likely to require the citizens of New Orleans to accept a diversion of reconstruction funds to environmental cleanup.

5. The lessons learned (or missed) from Katrina should be crystallized in a generic form so that the country as a whole will be better prepared for the next natural disaster, major industrial accident, or act of terrorism. Every effort should be made to put aside partisan concerns to solve real, significant problems concerning information processing during emergencies, and to make sensible, safe, and equitable cleanup/habitability decisions in an environment of great uncertainty. Because existing institutions were largely unprepared for a disaster of the scale of Katrina, it may not be possible to implement these principles in New Orleans. However, stakeholders can learn from Katrina and provide more effective responses to future catastrophes.



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Endnotes

[*] The first four authors of this article were participants in a symposium entitled ''Strengthening Scientific and Technical Responses to Hurricane Katrina: A Meeting of Experts'' under the auspices of the National Academies of Science (NAS) Nov. 14-15, 2005. One of subgroups at this symposium discussed the human health impacts of the then available data on contamination levels left in the wake of Hurricane Katrina and published an article in *Bridge*, a publication of the National Academy of Engineering in March 2006, summarizing some of the findings of that sub-session. An abridged version of the *Bridge* article also appears as an editorial in a recent issue of the Journal of Environmental Engineering. Since the NAS symposium in the fall of 2005, considerable additional information on current chemical concentrations in the sediment and soil in New Orleans became available.

Teresa Bowers joined on authoring this paper because she has experience with arsenic and lead soil cleanup sites.

[1] EPA and LDEQ also sampled soil in areas of known spills (such as the Murphy Oil spill), near known potential sources (such as near the Agricultural Landfill Superfund site), at schools, at the location of temporary housing, and in other media. For example, Murphy Oil Company collected more than 8097 sediment samples from 4859 properties at the site of a large oil tank spill in New Orleans. Results are available on EPA's Web page at http://www.epa.gov/katrina/testresults/murphy/index.html.

[2] EPA, *Summary Results of Sediment Sampling Conducted by the Environmental Protection Agency in response to Hurricanes Katrina and Rita at Phase I – Sediment from Floodwater*, available at http://epa.gov/Katrina/testresults/sediments/summary.html (August 17, 2006) (*EPA Aug. 17, 2006 Summary*).

[3] For example, Olga Pierce, *Health Risks in Katrina's wake* (March 28, 2006), United Press International Online, available at http://www.upi.com/HealthBusiness/view.php?StoryID=20060327-083234-3635r. The Natural Resources Defense Council (NRDC), a national environmental group, issued a report and press release with a number of extreme claims. Gina M. Solomon and Miriam Rotkin-Ellman, Natural Resources Defense Council, *Contaminants In New Orleans Sediment, An Analysis Of EPA Data*, (February 2006) (Report on file with National Resources Defense Council) available on the Web at http://www.nrdc.org/health/effects/katrinadata/sedimentepa.pdf at 3-4. (Hereinafter *Analysis of EPA Data*). *See also* Press Release, National Resources Defense Council, *State, Federal Officials Paper Over Toxic Contamination in New Orleans, Misleading Returning Residents About Health Risks, Groups Say* (Feb. 23, 2006) available at: http://www.nrdc.org/media/pressreleases/060223a.asp.

Similarly, a recent report carefully states that the arsenic concentrations are ''in excess of what the state and federals have established as screening levels,'' but does not explain what a ''screening level'' is or that the arsenic levels are within background. '' Sue Sturgis, *Tracking the Toxic Storm, Gulf Coast Reconstruction Watch, A Project of the Institute of Southern Studies*, available on the Web at http://www.reconstructionwatch.org/index.php?s=30&n=73.

[4] Environmental Protection Agency, *Environmental Assessment Summary for Areas of Jefferson, Orleans, St. Bernard, and Plaquemines Parishes Flooded as a Result of Hurricane Katrina* (Dec. 6, 2005) (Report on file with EPA) available at http://www.epa.gov/katrina/testresults/katrina_env_assessment_summary.htm . (Hereinafter *Assessment for Jefferson, Orleans, and St. Bernard*). The RECAP program Web page is http://www.deq.louisiana.gov/portal/Default.aspx?tabid=131.

[5] These risk management screening levels are based on the assumption that an adult would ingest 100 milligrams (mg) and a child 200 mg of such residential floodwater sediment 350 days per year for 30 years. *Assessment for Jefferson, Orleans, and St. Bernard*, *supra* note 4. An assessment of health risk is based on a comparison of the standard to the **average** concentration. Letter from LDEQ to NRDC (Feb. 2, 2006), *available at* http://www.deq.louisiana.gov/portal/portals/0/news/pdf/DEQ-EnvironmentalAssessmentKatrinaRita-NRDCResponse.pdf at 5. (*LDEQ Feb. 2, 2006 Letter*). More importantly, an individual's risk should be based on the average concentration of chemicals in the soil and sediment with which the individual will have long-term contact (*i.e.*, every day for 30 years). *Id*. at 5.

[6] United States environmental and safety regulations have long been based on health protective regulatory assumptions, even when there was ''no particular reason to think that the actual line of the incidence of harm is represented'' by the assumption selected by the regulatory agency. *Natural Resources Defense Council v. EPA*, 824 F.2d 1146, 1165; 26 ERC 1263(D.C. Cir. 1987) (unanimous en banc decision) (*NRDC v. EPA*). As a matter of policy and law, it is now well established that ''safe'' is not necessarily the same as ''risk-free,'' and mere exposure is not sufficient to support regulation unless there is a significant risk. *Industrial Union Dep't. v. API*, 448 U.S. 607, 642 (1980); *NRDC v. EPA*, 824 F. 2d, at 1164-1165.

[7] EPA, *Guidelines for Carcinogen Risk Assessment* at 1-7 (EPA/630/P-03/001B, March 2005), available at: http://www.epa.gov/iris/cancer032505.pdf. EPA and LDEQ use a regulatory risk assessments process to, among other things, determine whether contamination warrants remediation. Some view this methodology as overprotective and others view it as not protective enough. This article takes no position on this issue and simply assesses the results using these long-standing methodologies. We also have relied on the reported results and not performed any independent calculations of average concentrations or similar calculations that would require access to the individual data. All of the data cited is on EPA's Web site and can be found through the citations in these endnotes.

[8] *LDEQ Feb. 2, 2006 Letter*, *supra* note 5, at 5 (bold face added).

[9] *EPA Aug. 17, 2006 Summary*, *supra* note 2, at Phase I – Sediment from floodwater.

[10] *LDEQ Feb. 2, 2006 Letter*, *supra* note 5, at 3. *See also* LDEQ Press Release, *DEQ Puts Comprehensive Sampling-Result Maps on Web Site* (Feb. 15, 2006), *available at* http://www.deq.louisiana.gov/portal/portals/0/news/pdf/zipcodesfeb1306.doc, which discusses the fact that most of the 40 exceedences of LDEQ levels were from gutters and storm drains.

[11] This figure can be viewed in color on EPA's Web site. *EPA Aug. 17, 2006* , *supra* note 2, at Sediment Sampling Map. *See also Assessment for Jefferson, Orleans,*

and St. Bernard, *supra* note 4. EPA defined sediment from flood water ''as residuals deposited by receding flood waters which may include historical sediment from nearby water bodies, soil from yards, road and construction debris, and other material. *Id.* The initial phases sampled floodwater sediment deposited on land by the storm. Later phases also sampled surface soil that existed pre-Katrina or some combination. The documents sometimes refer to sediment, soil or soil/sediment.

[12] *Id*. at Phase I – Sediment from Floodwater.

[13] *LDEQ Feb. 2, 2006 Letter*, *supra* note 5, at 3.

[14] Petroleum products vary from gasoline to heavy crude oil. Each petroleum product is a mixture of specific chemicals, with a widely differing variety of chemical, physical, and toxicological properties. For convenience, environmental agencies typically require one of several analytical techniques to measure a portion of the entire mixture, such as measuring DRO to detect diesel fuel.

[15] This analytical technique measures the portions of petroleum products that are likely to be in gasoline (*i.e.*, the lighter end petroleum products).

[16] The summaries of the test results can be found on the Web at http://www.epa.gov/katrina/testresults/index.html. The entire EPA database for Hurricane Katrina can be accessed on the Web at http://oaspub.epa.gov/storetkp/dw_home.

[17] ATSDR, *Toxicological Profile for Total Petroleum Hydrocarbons* at 13 (September1999), available on the Web at http://www.atsdr.cdc.gov/toxprofiles/tp123.html (*ATSDR PAH Tox. Profile*).

[18] *LDEQ Guidelines for Assessing Petroleum Hydrocarbons*, Appendix D, available at http://www.deq.louisiana.gov/portal/Portals/0/technology/recap/2003/RECAP%202003%20Appendix%20D%20-%20final.pdf.

[19] *EPA Aug. 17, 2006 Summary*, *supra* note 2, at Phase I – Sediment from Floodwater.

[20] *Id*. at Phase I – Sediment from Floodwater.

[21] *Id*. at Phase II – Sediment from Floodwater.

[22] One cannot ascertain from the summaries provided by EPA online what percentage of the samples taken in Phase II from these four locations exceeded the lead level. *Id*. at Phase II – Sediment from floodwater. In any case, these results cannot be compared directly to some of the pre-Katrina sampling for lead in soil because that pre-Katrina sampling focused on property with home constructed prior to 1978 and the Phase II sampling focused on floodwater sediment. As discussed below, when EPA concentrated in Phase III on soil areas with known elevated levels, higher percentages of sediment containing lead were found. EPA states in its Phase III summary that the ''concentrations of lead found by EPA are consistent with the results'' from the prior sampling of New Orleans, although the summary does not address whether the percentage of samples are similar, higher or lower. *Id*. at Phase III – Focused Sampling of Flood Impacted Soil and Sediment.

[23] *Analysis of EPA Data*, *supra* note 3, at 14.

[24] One cannot ascertain from the summaries provided by EPA what percentage of the samples taken in Phase II from these four locations exceeded the lead level. *Id*. at Phase II – Sediment from Floodwater.

[25] *Id*. at Phase III – Focused Sampling of Flood Impacted Soil and Sediment; *Assessment for Jefferson, Orleans, and St. Bernard*, *supra* note 4; *LDEQ Feb, 2, 2006 Letter*, *supra* note 5, at 3; and *see* LDEQ Press Release, *DEQ Puts Comprehensive Sampling-Result Maps on Web site* (Feb. 15, 2006), *available at* http://www.deq.louisiana.gov/portal/portals/0/news/pdf/zipcodesfeb1306.doc, which discusses the fact that most of the 40 exceedences of LDEQ levels were from gutters and storm drains.

[26] *EPA Aug. 17, 2006 Summary*, *supra* note 2, at Phase III – Focused Sampling of Flood Impacted Soil and Sediment.

[27] *Id*. at Phase IV Sampling of Residual Sediment in Flood Impacted Areas.

[28] *Id*. at Phase IV Sampling of Residual Sediment in Flood Impacted Areas.

[29] That is, three samples out of 712 equal 0.4 percent of the samples taken in this phase. *Id*. at Phase IV Sampling of Residual Sediment in Flood Impacted Areas.

[30] Letter from Mike D. McDaniel, Commissioner of LDEQ to editors (Dec. 30, 2005), *available at* http://www.deq.louisiana.gov/portal/portals/0/news/pdf/McDaniel-LettertotheEditor123005.pdf. There may have been some exposure to residential floodwater sediment sampled in the first stage of the Phase I sampling that was removed during the Phase I sampling or thereafter. This residential floodwater sediment, therefore, by definition, is not a long -term risk because it has been removed. Additionally, few people stayed in the residential neighborhoods while the floodwaters remained.

[31] *Analysis of EPA Data*, *supra* note 3.

[32] Nationally, the range of arsenic background concentrations is up to 97 mg/kg. Gustavsson, N., B. Bølviken, D.B. Smith, and R.C. Severson, *Geochemical Landscapes of the Conterminous United States—New Map Presentations for 22 Elements*. U.S. Geological Survey Professional Paper 1648. Denver, Colo.: U.S. Geological Survey (2001) *available at* http://pubs.usgs.gov/pp/p1648/p1648.pdf at 15 of 44. According to USGS sampling data, the *mean* natural background concentration of arsenic nationally in surface soil is 7.2 mg/kg, with a range of 0.1 to 97 mg/kg. However, when geographic trends are taken into account, the mean concentration of arsenic in the soil in the Mississippi River basin is higher. By definition, individual concentrations are certain to exceed the mean. The mean natural background concentrations of arsenic in surface soil by states vary with mean concentrations ranging up to 11.7 mg/kg (for Ohio) (calculated by Dr. Bowers based on the USGS data for Ohio). Similarly, at the Heartland Superfund site in Illinois, EPA concluded that background level of arsenic in soil is between 10 to 17 mg/kg, available at http://www.epa.gov/region5/sites/cmcheartland/pdfs/faq-200609.pdf.

[33] EPA, *Soil Screening Level Guide* at 1 (OSWER No. 9355.4-23, July 1996), available on the Web at http://www.epa.gov/superfund/resources/soil/ssg496.pdf, and EPA, *Calculating Upper Confidence Limits For Exposure Point Concentrations At Hazardous Waste Sites* (2002, OSWER No. 9285.6-10), available on the Web at http://www.epa.gov/oswer/riskassessment/pdf/ucl.pdf at 4. LDEQ guidance states that if the average arsenic concentration at a site is ''less than or equal to the mean [average] background arsenic concentration [specified in the rule] then it should be concluded that a release has not occurred.'' LDEQ, *RECAP Frequently Asked Questions*, available on the Web at http://www.deq.louisiana.gov/portal/tabid/1566/default.aspx.

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The ''detection of a single chemical in soil that is greater than the screening level does not mean that health risks exist,'' but only that ″additional evaluation of available data and/or site conditions may be indicated.″ *LDEQ Feb. 2, 2006 Letter*, *supra* note 5, at 5 (bold face added).

[34] According to the NRDC analysis of the EPA's data, the average level of arsenic found by the EPA in the greater New Orleans area is 10.6 mg/kg of soil, and in Orleans Parish the average at the locations specifically selected to find contamination is 11.8 mg/kg or less. *Analysis of EPA Data*, *supra* note 3, at 4.

[35] Using the same assumptions EPA used in calculating the arsenic screening level, if the one in 1 million risk level is 0.4 mg/kg, the long-term risk from soil containing 11.8 mg/kg would be approximately 3 in 100,000 (i.e., 11.8 divided by 0.4 times x 10^{-6}). However, as noted by LDEQ, these assumptions are very conservative, nonsite specific. *LDEQ Feb. 2, 2006 Letter*, *supra* note 5 at 2-5.

[36] EPA has made this determination for superfund sites (40 C.F.R. § 300.430(e)(2)(i)(A)(2)), EPA, *National Oil Pollution and Hazardous Substances Contingency Plan*, (55 Fed Reg. 8666), at 8752 (1990) (1990 NCP), for drinking water nationally (40 C.F.R. § 141.32(e) (45), which states that 0.5 ppb of PCBs in drinking water, which corresponds to the $10^{-4,}$ is ''safe''), for EPA's sewage sludge regulations (which allows sludge containing 41 mg/kg of arsenic to be used in home gardens). *See* R. Chaney, U.S. Dep't of Agriculture and J. Ryan, EPA, *Risk-Based Standards for Arsenic, Lead and Cadmium in Urban Soils* at 55-56 (DECHEMA 1994)), among other programs. The courts uniformly have upheld EPA's determination that a 10^{-4} lifetime risk is ''safe.'' *See e.g.*, *Ohio v. EPA*, 997 F.2d 9520, 1532; 36 ERC 2065, 20075-76 (D.C. Cir., 1993) for superfund and in *NRDC v. EPA*, 824 F.2d 1146, 26 ERC 1263(D.C. Cir. 1987) (unanimous en banc) for the Clean Air Act.

LDEQ RECAP arsenic soil screening level of 12 mg/kg is below cleanup goals for arsenic selected by EPA at many superfund sites (e.g., 20 mg/kg at Record of Decision for Central Wood Preserving Company (2001), available at on the Web http://www.epa.gov/superfund/sites/rods/fulltext/r0601515.pdf at 40 of 93; 70 mg/kg at Vasquez Blvd & I-70 Superfund Site, CO (ROD, 2003); and 250 mg/kg at Anaconda Co. Smelter, MT (ROD, 1996)). These EPA cleanup decisions can be word searched on the Web at http://cfpub.epa.gov/superrods/index.cfm?fuseaction=main.search. *See also* A. Davis, D. Sherwin, R. Ditmars & K. Honeke, *An Analysis of Soil Arsenic Records of Decision*, Environmental Science and Technology 35(12): 2401-2406 (Davis 2001); P. Valberg, B. Beck, T. Bowers, T. Keating, J. Bergstrom, & P. Boardman, *Issues In Setting Health-Based Cleanup Levels for Arsenic in Soil*, Reg. Tox. and Pharm. 219-229 (Valberg 1997)

[37] *See, supra* note 27. In the case of New Orleans, much of the soil has been deposited over long periods of time from the Mississippi River. This river soil sediment seems to have the same natural arsenic background range as Louisiana soil in general. The United States Geological Survey study of arsenic levels in surface soil indicates that the average background of arsenic is approximately 10 mg/kg throughout the Mississippi River Delta region of south Louisiana. Additionally, at least one EPA study cites the range of natural background of arsenic in Louisiana as 1-32 mg/kg. EPA, *Record of Decision for the Louisiana Army Ammunitions Plant, Doyline, LA* (2000), which states that arsenic concentrations up to 16.9 mg/kg ''well within the natural range reported for Louisiana soils of 1-32 mg/kg (Dragun and Chaisson, 1991),'' available at http://www.epa.gov/superfund/sites/rods/fulltext/r0600163.pdf at 26, 27 . Similarly, a 20 mg/kg background level of arsenic in *Louisiana was determined in Record of Decision for Central Wood Preserving Company* (2001), available at http://www.epa.gov/superfund/sites/rods/fulltext/r0601515.pdf. at 40.

[38] *EPA Aug. 17, 2006 Summary*, *supra* note 2, at Summary.

[39] EPA, *Summary Assessment of the Results of Sampling of Localized Areas Identified For Focused Investigations Following Hurricane Katrina* (February 2006), available on the Web at http://www.epa.gov/katrina/testresults/sediments/focused_sampling.html (*February 2006 Summary*).

[40] *February 2006 Summary*, *supra* note 39; *Assessment for Jefferson, Orleans, and St. Bernard*, *supra* note 4.

[41] According to ATSDR, 4 mg/kg of B(a)P for 70 years corresponds to a ''theoretical increased cancer risk'' of ''less than 5 in 100,000 (5 x 10^{-5}).'' ATSDR Dec. 5, 2005 Health Consultation, *supra* note 9. Thus, 1.4 mg/kg corresponds to 1.9 x 10^{-5} (1.4 divided by 4 times 5 x 10^{-5}) assuming 70 years of exposure. If 30 years of exposure is used (as was assumed by EPA and LDEQ), the risk is less than 8 x 10^{-6} (1.9 x 10^{-5} x (30 years divided by 70 years)).

NRDC's average detectable concentration of diesel fuel in its sampling were 524.1 mg/kg of sediment in Orleans Parish and 956.8 mg/kg in Bernard Parish. Analysis of EPA Data, *supra* note 3, at 7. Most, if not all, of the representative compounds relied upon by ATSDR in evaluating the aromatic fractions of petroleum (benzene, toluene, ethylbenzene, xylenes, naphthalene, fluorene, and B(a)P) (*see* ATSDR PAH Tox. Profile, *supra* note 15, at 15) and were looked for in the sediment in New Orleans and not found. Even using the NRDC calculation, the average concentration of 524.1 mg/kg of diesel fuel in the greater New Orleans area is below the LDEQ screening level. However, NRDC calculation appears to includes areas of known oil spills, such as the Murphy Oil site in Chalmette.

[42] *EPA Aug. 17, 2006 Summary*, *supra* note 2, at Diesel and Oil Range Organic Hydrocarbons. The average concentration of the biodegradable chemicals, such as various petroleum products, ''is expected to decrease over time due to growth of vegetation and the degradation and dispersion of these chemicals from natural processes in the environment.'' *Assessment for Jefferson, Orleans, and St. Bernard*, *supra* note 4. *See also* Deputy Administrator Peacock Briefs Reporters on EPA Efforts in Gulf Coast: Transcript of Sept. 16 Press Conference (Sept. 16, 2005) available at http://www.epa.gov/katrina/newsroom/091605transcript.htm.

[43] LDEQ, *Overview of Post-Katrina Data for Zip Code 70092*. available on the Web at http://www.deq.louisiana.gov/portal/portals/0/zipdata/data/70092.pdf at 3 and *Assessment for Jefferson, Orleans, and St. Bernard*, *supra* note 4.

[44] *February 2006 Summary*, *supra* note 39.

[45] EPA's lead rule is codified at 40 CFR § 745.65(c). It requires remediation of ''bare soil on residential real property or on the property of a child-occupied facility

that contains total lead equal to or exceeding 400 . . . mg/kg . . . in a play area or average of 1,200 . . . [mg/kg] of bare soil in the rest of the yard based on soil samples.'' *Id*. Section 104(a)(3) of CERCLA, 42 U.S.C. § 9604(a)(3) excludes from CERCLA actions to clean up releases from structures within buildings. This article does not address the question of whether lead in soil, which has migrated from the old lead-based paint in a structure is within CERCLA's jurisdiction.

[46] *LDEQ Feb. 2, 2006 Letter*, *supra* note 5 at 2-5. A 20 mg/kg background level of arsenic was determined in Record of Decision for Central Wood Preserving Company (2001), available on the Web at http://www.epa.gov/superfund/sites/rods/fulltext/r0601515.pdf. at 40.

[47] In a very limited location, the initial sampling found what appears to be elevated concentrations of arsenic in locations on or near golf courses where arsenic-based herbicides are typically used. *LDEQ Feb. 2, 2006 Letter*, *supra* note 5, at 4-7. These elevated arsenic levels were not storm related, were not accessible to the general public, and, in LDEQ's judgment, ''did not pose a health risk to nearby residential areas.'' *Id*. Subsequent sampling indicates the average arsenic concentration in these areas does not present a significant risk. EPA, *Summary Assessment of the Results of Sampling of Localized Areas Identified For Focused Investigations Following Hurricane Katrina*, available at http://www.epa.gov/katrina/testresults/sediments/focused_sampling.html (last updated April 4, 2006).

[48] Using the same assumptions that EPA used in calculating that the arsenic screening level, if the one in 1 million risk level is 0.39 mg/kg, the long-term risk from soil containing 11.8 mg/kg would be approximately 3 in 100,000 (i.e., 11.8 divided by 0.39 times x 10^{-6}). However, as noted by LDEQ, these assumptions are very conservative, nonsite specific. *LDEQ Feb. 2, 2006 Letter*, *supra* note 5, at 2-5.

[49] N. Gustavsson, B. Bølviken, D.B. Smith, & R.C. Severson (2002) *Geochemical Landscapes of the Conterminous United States—New Map Presentations for 22 Elements*. U.S. Geological Survey Professional Paper 1648. Denver, Colo.: U.S. Geological Survey, *available at* http://pubs.usgs.gov/pp/p1648/p1648.pdf at 28.

[50] *Analysis of EPA Data*, *supra* note 3, at 14.

[51] Agency for Toxic Substances and Disease Registry (ATSDR) *Public Health Consultation for Murphy Oil Spill* (Dec. 9, 2005), available on the Web at http://www.bt.cdc.gov/disasters/hurricanes/katrina/murphyoil/consultation_120905.asp and LDEQ, *Guidelines for Assessing Petroleum Hydrocarbons, Appendix D*, available at http://www.deq.louisiana.gov/portal/Portals/0/technology/recap/2003/RECAP%202003%20Appendix%20D%20-%20final.pdf. LDEQ RECAP Table 2, Management Option 1, Standards for Soils at T 2 - 4, available on the Web at http://www.deq.louisiana.gov/portal/Portals/0/technology/recap/2003/RECAP%202003%20Text%20Tables%202,3,%20Appendix%20H%20Table%205.pdf at 4 . NRDC used a diesel fuel residential screening level of 65 mg/kg for DRO (which is the screening level, not the Management Option 1 Standard). LDEQ RECAP Table 1, Screening Option, Screening Standards for Soils and Groundwater available at http://www.deq.louisiana.gov/portal/Portals/0/technology/recap/2003/RECAP%202003%20Text%20Table%201.pdf at 5.

[52] EPA Region 6's internet version of *Risk-Based Human Health Screening Values* can be found on the Web at http://www.epa.gov/arkansas/6pd/rcra_c/pd-o/../pd-n/screen.htm. LDEQ RECAP (Oct. 20, 2003) is available on the Web at *http://www.deq.louisiana.gov/portal/Portals/0/technology/recap/2003/RECAP%202003%20Text%20-%20final.pdf*. LDEQ RECAP Worksheet 4, Soili, Soil Industrial, at WH4-39, Derivation of Standards for Management Option 1 & 2, available on the Web at *http://www.deq.louisiana.gov/portal/Portals/0/technology/recap/2003/RECAP%202003%20Appendix%20H%20Tables%201,2,4,%20Worksheets%201-6,9-16.pdf* at 39.

[53] ATSDR PAH Tox. Profile, *supra* note 15, at 13.

[54] H.W. Mielke, et al., *PAH and Metal Mixtures in New Orleans Soils and Sediments*. Sci. Total Environ. 281 (1–3), 217–227 (2001).

[55] LDEQ RECAP Worksheet 4, Soili, Soil Industrial, at WH4-45, Derivation of Standards for Management Option 1 & 2, available on the Web at *http://www.deq.louisiana.gov/portal/Portals/0/technology/recap/2003/RECAP%202003%20Appendix%20H%20Tables%201,2,4,%20Worksheets%201-6,9-16.pdf* at 45. *E.g., ATSDR, Public Health Consultation for Murphy Oil Spill (Dec. 9, 2005), available on the Web at http://www.bt.cdc.gov/disasters/hurricanes/katrina/murphyoil/consultation_120905.asp*.

[56] ATSDR, *Public Health Consultation for Murphy Oil Spill* (Dec. 9, 2005), available on the Web at http://www.bt.cdc.gov/disasters/hurricanes/katrina/murphyoil/consultation_120905.asp.

[57] *Id*.

[58] LDEQ, *Overview of Post-Katrina Data for Zip Code 70092* (Jan. 18, 2006) available on the Web at http://www.deq.louisiana.gov/portal/portals/0/zipdata/data/70092.pdf. Conceptually, sampling for screening purposes is analogous to eliminating all of the As and Bs in a report card to focus on the subjects in which a student needs to expend additional effort. While it does focus on the areas where more work is needed, it provides a misleading view of the overall picture because it significantly lowers the actual grade average of the student (*e.g.*, a B+ student appears to be a C or D- student if all As and Bs are removed from the calculation of their average grade).

[59] The locations found to contain lead concentrations above 400 mg/kg in the fall of 2005 during the initial sampling (*i.e.*, approximately 5-7 percent of the areas sampled in the fall of 2005) were resampled in February 2006. This later resampling only found 57 of the original 147 sample locations (39 percent) exceeded 400 mg/kg. *February 2006 Summary*, *supra* note 39. Thus, some locations have higher frequency of lead exceedances than others..

In fact, according to the NRDC analysis, 95 percent and 93 percent, respectively, of the Greater New Orleans and Orleans Parish soil samples from the locations most likely to be contaminated did *not* exceed 400 mg/kg lead level typically used as a soil screening level in the U.S. site. *Analysis of EPA Data*, *supra* note 3, at 12.

[60] *February 2006 Summary*, *supra* note 39. Historic lead sources include use of leaded gas, lead paint, and emissions from now-mothballed garbage incinerators.

[61] *Id*. at Phase III – Focused Sampling of Flood Impacted Soil and Sediment.

[62] *Analysis of EPA Data*, *supra* note 3, at 12.

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[63] Mielke, H.W., et al., *PAHs and Metals in the Soils of Inner-City and Suburban New Orleans, Louisiana, USA*. Environmental Toxicology and Pharmacology 18(3): 243–247 (2004). *See* ES&T News, Lead a Hazard in Post-Katrina sludge, available on the Web at http://pubs.acs.org/subscribe/journals/esthag-a/40/i02/html/011506news3.html. It appears that this pre-Katrina sampling may have focused on locations where housing was old and close to the homes.

[64] *Id*.

[65] *EPA Aug. 17, 2006 Summary*, *supra* note 2, at Section Conclusions and Recommendations. For children aged <6 years, CDC has defined an elevated blood lead level (BLL) as >10 μg/dL, The 14 percent for children in New Orleans is higher than the national average of 6 percent. CDC, *Mortalitiy and Morbidity Weekly Report, Blood Lead Levels in Young Children—United States and Selected States, 1996—1999*, Dec. 22, 2000 / 49(50); 1133-7, available on the Web at http://www.cdc.gov/mmwr/preview/mmwrhtml/mm4950a3.htm#fig1 .

[66] *EPA Aug. 17, 2006 Summary*, *supra* note 2, at Section Conclusions and Recommendations

[67] E. Marris, *New Orleans Cleared of 'Toxic Soup' Scenario, Surveys Show No Evidence of Long-Term Health Risks Caused by Katrina*. published in news@nature.com (Sept. 15, 2006) (doi:10.1038/news060911-14), available on the Web at http://www.nature.com/news/2006/060911/full/060911-14.html.

[68] *Id*.

[69] NRDC *New Orleans Environmental Quality Test Results* (2005). Available on the Web at http://www.nrdc.org/health/effects/katrinadata/contents.asp.

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